the weather side. Thus the increase of amplitude is a steady process, whereas the increase of the wave-length (if determined by measurement along one or two sections of a few ridges) takes place *per saltum*, or, as Dalton might have said, in "multiple proportion."

It is pointed out that the tidal sand ridges, by their size, orientation, and lateral extension, afford an admirable means of mapping the tidal currents in those estuaries in which circumstances secure their preservation on the sand-banks visible above low-water mark.

Between the date of the writing and the publication of this paper the author observed in Canada the formation of long trains of waves of snow, by a process similar to that which creates these sand waves. They are distinct altogether from the ripples of drifted granular snow, which were also observed

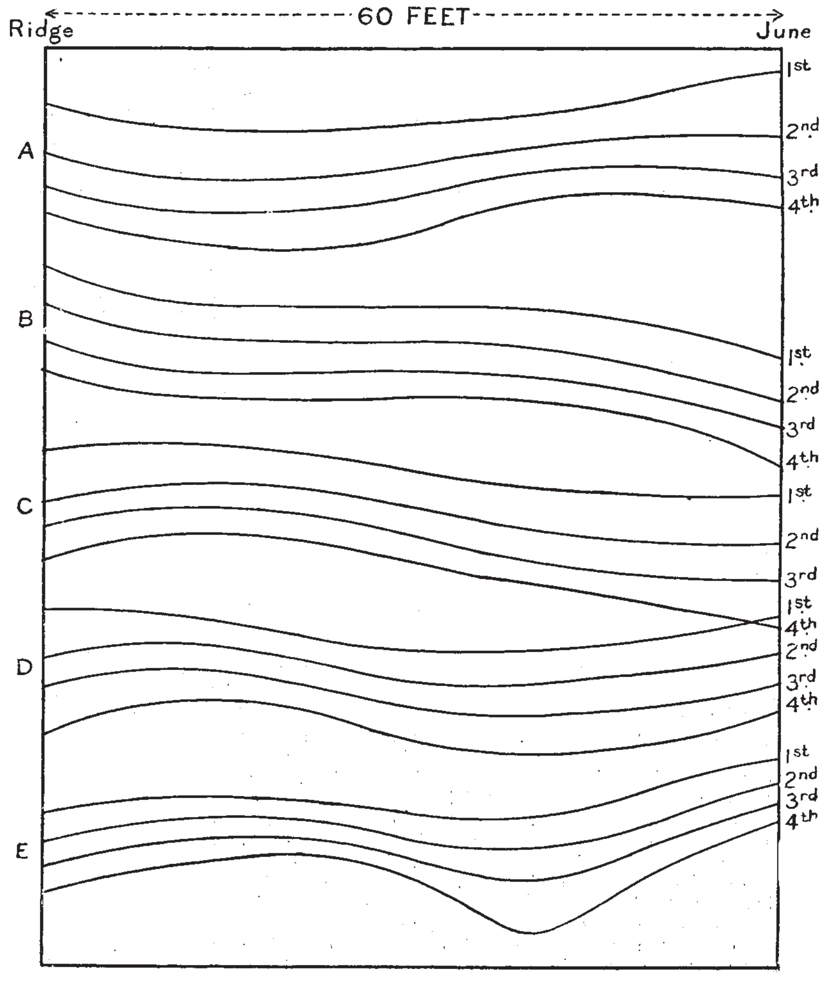

FIG. 3.—Plan of five sand ridges showing positions on four succeeding days, Dovey Estuary. Scale, 1 inch = 16 feet.

WOAD AS A BLUE DYE.[1]

MR. E. CORDER[2] has so thoroughly gone into the matter of East Anglian woad culture and preparation that the present remarks must be regarded as quite supplemental to his paper, having been, in fact, inspired by it. Frequent visits have been made to the Parson Drove Woad Mill, and a long series of experiments conducted before the blue colour, the indigo in fact, in this woad could be demonstrated. Curiously enough, the subject has engaged the attention of Prof. Beyerinck, of Delft, and by his help the presence of indigo was easily shown in the fresh plant from Parson Drove. The blue colour of woad is indigo—the same substance chemically as that obtained from *Indigofera tinctoria* and *Polygonum tinctoria*. There is this great difference however: in the last named plants it exists in a form which is easily extractable, whereas in woad it exists in a condition which is the very reverse.

In 1855, Dr. E. Schunck, in an exhaustive paper on the chemistry of woad, drew attention to the fact that indigo did not exist as ready formed indigo-white in this plant. He showed that the glucoside indican was the form from which indigo-white was produced by oxidation. In 1877, M. Alvarez attributed the formation of indigo to the action of bacteria, but in 1898 Bréaudat demonstrated that microbic life was not necessary.

Marchlewski and Radcliffe consider indican consists of sugar and a very unstable substance called indoxyl. Prof. M. W. Beyerinck holds the view that the indigo producing plants may be divided into two groups, in one of which this substance exists as indican (*Indigofera tinctoria* and *Polygonum tinctoria*), while in the other (of which woad, *Isatis tinctoria*, is the type) it exists as indoxyl. More recently, however, Beyerinck has come to the conclusion that even indoxyl does not exist ready formed in woad, but that it exists as a "loose compound" isatan, which by an enzyme isatase also present in woad is easily decomposed into indoxyl.

Be this as it may, it is not difficult to extract indigo blue from fresh woad leaves by the process given by Beyerinck. This consists in packing fresh woad leaves into a stoppered bottle and filling the bottle entirely with boiling water, inserting the stopper so that no air-bubble is left between it and the top of the water; after a few hours the infusion will be found of a pale yellow colour, having, when cold, a green fluorescence. If an alkali be added to this infusion and air blown through it, indigo blue is precipitated on the further addition of an acid. Woollen articles dipped into this alkalised infusion become, on exposure to the atmosphere, a pale azure blue. This change, however, takes place far more rapidly if they be dipped into acidulated water. The indigo thus obtained is, however, very apt to contain impurities; notably, to pass into a condition known as indigo-brown, in which an insoluble black-brown substance is formed which is useless to the dyer and cannot be reconverted into indigo blue. During the unsettled state of Europe towards the end of the eighteenth and beginning of the nineteenth century, numerous attempts were made to manufacture indigo directly from woad; prizes were offered by various Governments for the attainment of this object in order that the use of foreign indigo might be obviated, as it could only be obtained with difficulty. None of these processes were ever practically successful. Many of them were entirely theoretical. Some sought to obtain indigo by macerating fresh woad leaves in cold water, others in warm water, others by infusing them in boiling water and subsequently washing with cold.

To demonstrate the presence of indigo in the woad leaf, the process of Dr. Hans Molisch is the best. This consists in keeping the fresh leaves in a wide-mouth stoppered bottle, filled with gaseous ammonia for twenty-four hours, and then dissolving out the chlorophyll by immersing the leaves for a like period in absolute alcohol. Sections show that the indigo is confined to those tissues which contain chlorophyll, and that the hairs,

[1] Abridged from a paper by Dr. C. B. Plowright, in the *Transactions* f the Norfolk and Norwich Naturalists' Society, vol. vii. 1900–1901.
[2] Corder, E. *Trans.* Norfolk and Norwich Nat. Soc., 1890, vol. v. p. 144.

cuticular cells (excepting the guard cells of the stomata) and fibro vascular bundles are free from it. When the chlorophyll has been thus extracted, the leaves have a blue colour of greater or less depth according to the amount of indigo they contain.

Although the extraction of indigo is so difficult and unsatisfactory a process, yet woad has been used as a blue dye from remote antiquity. Pliny refers to it as having been used to stain chalk blue for the adulteration of indigo, which was then a pigment of great rarity, as it had to be imported by the "overland route" from India.

The first printed reference to woad as a blue dye occurs in Ruellius ("De Natura Stirpium," 1536), who remarks in words of which the following is a translation:—"They crush the green plant in mills, so as to expel the vegetable juices, then when the moisture has been removed they make the woad up into large balls, and these they allow to lie on the floor and decay till they fall into ashes (dust). In many places they call woad 'pastel,' from the loaf like shape into which the woad balls are made up. They heat (the dust of) these balls in vats, in dyers' shops and dip woollen cloths and skins therein, that they may absorb the blue colour. The blue scum floating on the surface, which the vats throw up when warming on the fire, our dyers call indigo; this they dry for the use of painters."

In 1555 Crolach published his small book on woad and its culture and preparation, from which it appears that Thuringia, one of the great woad producing districts of Europe, was already beginning to feel the effect of the introduction of indigo into Western Europe by the Cape route. A century later this was more pronounced, judging from what Wedelius says. His account of the woad industry is very good; so much so that Ray, the first professor of botany at Cambridge, copies it almost verbatim with due acknowledgment, which in its turn was copied and translated by the author of the English edition of Tournefort's "Herbal." The latter tells us, "the ground, which is plow'd in *Autumn*, must be left all *Winter* to be soak'd by the rain, till *the Purification of Our Lady*. After *Lady Day*, when the air is somewhat softer and milder, it is proper to sow it, and your end will be better answer'd if you sprinkle a little snow over it, and take care that you do not sow it too thick . . . . and after *Whitsuntide* you must weed all other herbs from it. After *St. John's Day* in the Beginning of Harvest it is ripe." It is interesting to add that the wadmen of the present day say that, "no wad should be gathered after Martimas Day" (November 15). Wedelius was essentially a chemist, and the main object of his book was to show that ammonia was produced from plants. He showed that ammonia was given off in large quantities during the couching of woad, and he also argued on theoretical grounds that woad contained sulphur, in both of which assertions he was correct. He tells us, as early as 1577 a decree was made at Frankfort to prevent the fraudulent and injurious substitution of indigo for woad, and on April 21, 1654, at Ratisbon, an edict was promulgated inflicting the penalty of confiscation against the further importation of indigo. The days of woad as a dye were, however, rapidly drawing to an end, and yet, paradoxical as it may seem, the dyers of the "greater dye" could not do without it. At this time no other equally good method was known by which indigo could be dissolved and used for dyeing. We find woad culture an important industry during the seventeenth and eighteenth centuries; accounts are to be found in the contemporary agricultural writers—Ellis, Trowell, Miller and Young. It was mostly carried on by itinerant "wadmen," who, with their families, travelled from place to place, growing the woad on newly broken up pasture land for which very high rents were paid. These gangs built their huts and wad mills with the sods from off the land, and were brought up to the industry from their childhood. They seldom stayed more than two or three seasons in the same spot, moving to a fresh location as soon as the soil became exhausted. Abroad Schreber's monograph, published in 1752, gives a very complete account, not only of the culture, but of the history of the subject, as well as copious extracts from the more important writers on the subject, with copies of the various proclamations, edicts, &c. In the appendix to this volume a German translation is given from Hellot's chapter on dyeing wool with indigo and woad. This book (Hellot's) was subsequently translated into English, anonymously. Under the "greater dye" or dyeing "colours in grain," it gives the *modus operandi* of working a woad or pastel vat, which was the best then known way of dyeing with indigo. The directions are sufficiently quaint; for instance, the writer begins by saying, "Your copper cauldron should be placed as near as possible to the vat and then filled with pond water: if the water be not sufficiently putrid you put in a handful of hay. When the copper is full the fire should be lighted under it at three o'clock in the morning." Then again, for every ball of pastel you throw in a full measure of *ware* (slaked lime), and sundry mysterious stirrings and coverings are enjoined, until the vat has "come to." When the indigo is put into it, there follow more stirrings and additions of ware, until the vat is ready for the "overture," or first piece of stuff to be dyed. "Towards the latter end of the week you dye the light blues, and on Saturday night, in order to preserve it 'till Monday, you *garnish* with a little more ware than on the day preceding." On Monday morning the vat was reheated, fresh indigo added to replace that which had been taken out by articles dyed during the preceding week, while bran and lime were added in the proper proportions. In point of fact a woad vat, once started, was kept going for many weeks or months, adding the indigo from time to time as required, as well as the requisite proportion of bran (sharps) and slaked lime (ware). The whole process was an exceedingly delicate one; if the lime was deficient the vat became putrid, if used too freely the vat "got the kick" and did not work at all; this was also the case if the proper temperature was not maintained.

What really takes place in a woad vat is concisely this:—Indigo blue is a very insoluble substance; it will not dissolve in any of the ordinary solvents, such as hot or cold water, dilute acids, alkalies, alcohol, ether, chloroform, &c. Hence it is a very fast dye if it can only be made to attach itself to a fabric. In order that this may be done, it is necessary to dissolve it; but, as we have seen, none of the ordinary solvents will do this. In the woad vat the chemical composition of the insoluble indigo-blue is altered; it is, as chemists say, reduced to indigo-white; now indigo-white is soluble in weak alkaline solution, hence the use of the slaked lime. If a skein of wool be dipped into a vat containing indigo-white in this state, the solution soaks into the tissues of the wool fibres; when the wool is taken out and exposed to the air, the oxygen unites with the reduced indigo and the skein passes from a greenish-yellow to a deep blue, the insoluble indigo-blue being thus formed and the fabric dyed in such a way that no mordant is required. The chemical changes which take place in the woad vat when once started are, that the starch of the bran is converted into grape sugar, which becomes lactic acid. The lactic acid becomes butyric acid, and in so doing nascent hydrogen is liberated, which reduces the indigo to indigo-white. Indigo is soluble in strong sulphuric acid, and there are other processes by which it can be reduced; but the above is the rationale of the woad vat, which has held its own from the time when the mediæval dyers added a little indigo to the vat to improve the colour of the blue down to this present time. It is an expensive, awkward and difficult process, but it has this one advantage—the colour produced is extremely durable. In actual practice a little madder is added; this is done, the dyers say, "to kill the green" in the indigo.

Woad was used long before indigo came into Europe, not as a solvent, but as a dye *per se*. Woad contains no indigo ready formed; not the slightest trace of any blue colour can be detected in it. With water it forms a dark brown mixture, which colours woollen fabrics olive-green. In order to dye with woad, all that is necessary is to pour boiling water on the woad and keep it in a well-covered vessel for fifteen or twenty hours at a temperature of about 110° to 140° F., not going above 150° or letting it fall below 100°. In about thirteen to fourteen hours bubbles of gas begin to rise; a very small quantity of slaked lime should now be added, and in a few hours woollen articles allowed to remain in it for an hour or two change from yellow to blue as they are taken out and exposed to the air. When the vat is in full working order the liquid is of an olive-brown colour, on the surface of which darker veins appear which change their position, slowly moving, appearing and disappearing spontaneously. The froth which at this time gathers on the surface of the vat is blue from the indigo precipitated by contact with the atmosphere. This constitutes the *caeruleum spumam* Ruellius speaks of as being dried and sold to the painters. It was also the "flowers of the woad" which the dyers of Coventry were accused of skimming off the woad vats in which they dyed their customers' goods and added to those vats in which they

dyed their own. It is interesting to notice that, if a skein of wool be suspended in a small experimental vat in good working order, it is the upper part of the skein nearest the surface which takes the deepest colour, and next to it, as one would have imagined, the lower part nearest the sediment at the bottom. This blue scum was the probable source, not only of the woad blue which Pliny speaks of as being used in his time to stain chalk with for the adulteration of indigo, but also of the "ancient Briton" pigment, of which we hear so much and know so little. Cæsar and Pomponious Mela speak of our ancestors staining their bodies blue; it is difficult to understand how they could dye their skin blue, but it is easy to see how they could have smeared themselves with woad-blue mixed with oil or grease. Herodian, however, throws a little more light on the subject when he tells us that "they mark their bodies with various figures of all kinds of animals, which is the reason they wear no clothes, for fear of hiding these figures." The use of indigo for tattooing is still common among our soldiers and sailors.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

DR. J. T. JENKINS has been appointed lecturer in biology and geology at the Hartley College, Southampton, and Mr. J. D. Coates assistant lecturer in physics and electrical engineering.

MISS ELEANOR ORMEROD, the well-known authority on agricultural entomology, lately deceased, bequeathed the sum of 5000*l.* to the University of Edinburgh. Miss Ormerod was an examiner in entomology for the University, and received from them last year the degree of LL.D.

THE councils of English Counties and County Boroughs expend upon scholarships a large amount of the money available for technical education. A report upon the scholarship schemes adopted by local authorities appears in the *Record* of Technical and Secondary Education, and it shows what is being done to provide continuous and systematic courses of training for promising students. It appears from this report that, taking County and County Borough Councils together, there are now 93 out of 110 such local authorities who provide scholarships in one form or another. The total number and value of the scholarships and exhibitions in force (*i.e.* those awarded and those continued and renewed from previous years) under the schemes of 90 of those 93 authorities during the year 1899–1900 were 19,971 and 156,793*l.* respectively. The scholarships are tenable at institutions of various ranks, and the number and value of those awarded annually in each class are as follows:—(1) At evening classes, 6766 (7862*l.*); (2) at technical and science and art schools, 3426 (17,064*l.*); (3) at secondary schools, 5593 (77,349*l.*); (4) at higher institutions and Universities, 679 (27,097*l.*); (5) at agricultural and horticultural schools, &c., 532 (9866*l.*); (6) at domestic science schools, &c., 1349 (12,199*l.*); (7) for elementary teachers, 1626 (5356*l.*). A comparison of these figures with similar returns obtained five years ago shows that a considerable increase has taken place in the number of scholarships tenable at permanent technical schools.

SCIENTIFIC SERIAL.

American Journal of Science, August.—Experiments on high electrical resistances, by O. N. Rood. The units of resistance employed were prepared by painting peroxide of manganese on strips of blue cobalt glass, then drying and immersing in a rosin wax bath at 150° C. It was found that the surface conduction of units prepared in this way in ordinary weather was practically zero. The aluminium leaf electrometer used in the measurements is also described. It was found possible to build up a set of high resistances with values from 32,000 to 14,000,000 megohms.—Mineralogical notes, by A. J. Moses. A description of mercuric iodide from New South Wales, some new forms on Bergen Hill pectolite and on atacamite crystals from Chili, realgar crystals from Snohomish County, Washington, vesuvianite from New Mexico, chrysoberyl from New York City, and a pyroxene crystal from the copper mines of Ducktown, Tenn.—On the motion of compressible fluids, by J. W. Davis.—The action of sodium thiosulphate on solutions of metallic salts at high temperatures and pressures, by J. T. Norton, jun. Solutions of various salts which are incompletely precipitated by sodium thiosulphate at the ordinary temperature were heated under pressure in sealed tubes at 120°–140° C. In many cases the reaction became complete, the whole of the metal being precipitated as sulphide or hydroxide. In a few cases the reaction was indeterminate.—Secondary undulations shown by recording tide gauges, by A. W. Duff.—Mathematical notes to rival theories of cosmogony, by O. Fisher.—Studies of Eocene Mammalia in the Marsh collection, Peabody Museum, by J. K. Wortman.—The electromagnetic effects of moving charged spheres, by E. P. Adams. The deflection of a magnetic needle caused by the rotation of two electrically charged spheres was measured, and in opposition to the views recently published by Cremieu, the deflections observed agreed with those calculated theoretically within the limits of experimental error.—The nadir of temperature and allied problems, by J. Dewar.

SOCIETIES AND ACADEMIES.

LONDON.

Royal Society, June 20.—On the Behaviour of Oxy-hæmoglobin, Carbonic-oxide-hæmoglobin, Methæmoglobin and certain of their Derivatives, in the Magnetic Field, with a Preliminary Note on the Electrolysis of the Hæmoglobin Compounds, by Arthur Gamgee, M.D., F.R.S., Emeritus Professor of Physiology in the Owens College, Victoria University.

The following are the conclusions to which the author has been led by his experiments:—

(1) The blood-colouring matter, oxy-hæmoglobin, as well as carbonic-oxide hæmoglobin and methæmoglobin, are decidedly diamagnetic bodies.

(2) The iron-containing derivatives hæmatin and acethæmin are powerfully magnetic bodies. The differences in magnetic behaviour between the blood-colouring matter and acethæmin and hæmatin point to the profound transformation which occurs in the hæmoglobin molecule when it is decomposed in the presence of oxygen.

(3) The preliminary study of the electrolysis of oxy-hæmoglobin and CO-hæmoglobin renders it probable that, in the blood-colouring matter, the iron-containing group, on which its physiological properties depend, is (or is contained in) an electro-negative radical; according to analogy, the iron in such a compound would possess diamagnetic and not magnetic properties.

PARIS.

Academy of Sciences, August 12.—M. Fouqué in the chair.—A criterion for the recognition of singular points of the uniform branch of any monogenous function, by M. G. Mittag-Leffler.—On the infinitely small deformation of an elastic ellipsoid submitted to known forces on its boundaries, by MM. Eugène and Francois Cosserat.—Verification of the relation which exists between the characteristic angle of deformation of metals and the coefficient of restitution of their elasticity, by M. G. Gravaris.—On the colour of the ions, by M. G. Vaillant. The theory of ions applied to the coloration of solutions leads to the following consequences: in completely dissociated solutions containing only one coloured ion, the coloration is independent of the nature of the other ion; if the ionisation is incomplete, the coloration should vary with the concentration and nature of the non-coloured ion; and, finally, the coloration of a solution of any concentration ought to be related to its degree of dissociation by a formula with two moduli, and two only. All these conclusions were confirmed experimentally by a study of solutions of the permanganates of potassium, barium and zinc.—On the value of the molecular heats at the boiling point, by M. de Forcrand.—The action of benzoyl chloride upon trioxymethylene in presence of zinc chloride, by M. Marcel-Descudé.—A method for the prevention of hail, by